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Maritimes Region

Proceedings of the Regional Peer Review of the Stock Framework for American Eel (*Anguilla rostrate*) and Elvers

October 26-27, 2016
Dartmouth, Nova Scotia

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A regional peer review meeting was held on October 26-27, 2016, at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia to conduct a review of the framework for American Eel and elvers. The focus of the meeting was to review the science information basis to conduct an assessment of resource status and for the provision of management advice in a manner consistent with the Fisheries and Oceans Canada (DFO) precautionary approach. Participation in this meeting included DFO Science, Resource Management and Fisheries Protection Program, First Nations and aboriginal organizations, fishing industry, non-DFO scientists, Environmental Non-Governmental Organizations (ENGOs), and industry.

The status of the eel and elver fisheries in the Maritimes Region was last assessed in 1996 (Jessop 1996a, b). More recently, indices of general status were compiled in support of a national pre-COSEWIC and Recovery Potential Assessment of the American Eel (Bradford 2013; DFO 2014) and to help measure progress towards reducing human-induced mortality by 50 percent (DFO 2010). The 2012 COSEWIC assessment designated the American Eel as Threatened. They are currently under consideration for listing under the *Species at Risk Act* (COSEWIC 2012).

This Proceedings document constitutes a record of meeting discussions and conclusions, and any statements within should not be attributed as being consensus-based. A Science Advisory Report will not be a product of the meeting.

Compte rendu de l'examen régional par les pairs du Cadre d'évaluation du stock d'anguille américaine (*Anguilla rostrata*) et d'anguillette

SOMMAIRE

Une réunion d'examen par les pairs s'est déroulée les 26 et 27 octobre 2016 à l'Institut océanographique de Bedford à Dartmouth, en Nouvelle-Écosse, dans le but d'effectuer un examen du Cadre d'évaluation du stock d'anguille américaine et d'anguillette. La réunion portait principalement sur l'examen des renseignements scientifiques de base afin d'effectuer une évaluation de l'état des ressources et de fournir des conseils en matière de gestion d'une manière conforme à l'approche de précaution que privilégie Pêches et Océans Canada (MPO). Les participants à cette réunion comprenaient des représentants du Secteur des sciences et du programme de Gestion des ressources halieutiques et de protection des pêches du MPO, des Premières Nations et d'organisations autochtones, de l'industrie de la pêche ainsi que de scientifiques qui ne travaillent pas pour le MPO, d'organisations non gouvernementales de l'environnement et de l'industrie.

L'état des pêches à l'anguille et à l'anguillette dans la Région des Maritimes a été évalué pour la dernière fois en 1996 (Jessop 1996a, b). Récemment, des indices sur la situation générale ont été recueillis dans l'optique d'un examen national pré-COSEPAC et d'une évaluation du potentiel de rétablissement de l'anguille d'Amérique (Bradford 2013; MPO 2014), ainsi que pour permettre de mesurer les progrès relatifs à la réduction de 50 % de la mortalité d'origine anthropique (MPO 2010). En 2012, l'évaluation du COSEPAC a désigné l'anguille d'Amérique comme une espèce menacée. On envisage actuellement son inscription à la liste visée par la *Loi sur les espèces en péril* (COSEPAC 2012).

Le présent document est un compte rendu des discussions et des conclusions de la rencontre. Les énoncés s'y trouvant ne devraient pas être considérés comme fondés sur le consensus. Aucun avis scientifique ne sera produit à la suite de la réunion.

INTRODUCTION

The American Eel (*Anguilla rostrate*) is a widely distributed fish that occurs from northern South America to Greenland and Iceland. In Canada, the American Eel can be found in nearly all the accessible fresh, brackish and coastal waters from the Canada-United States of America border in the south to Lake Melville, Labrador, in the north, including the Laurentian Basin (Ontario and Quebec) and the island of Newfoundland. They have historically been fished for commercial and recreational purposes and by indigenous peoples for Food, Social, and Ceremonial (FSC) purposes throughout much of their Canadian range. The commercial fishery in the Maritimes Region is the only commercial eel fishery in Canada that includes the removals of eels as recruits, as well as juveniles and adults.

The status of the eel and elver fisheries in the Maritimes Region was last assessed in 1996 (DFO 1996). More recently, indices of general status were compiled in support of a national meeting to inform the assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (DFO 2010) and for a Recovery Potential Assessment of the American Eel (DFO 2014). In 2012, COSEWIC assessed the American Eel as Threatened (COSEWIC 2012). The species is currently under consideration for listing under the *Species at Risk Act* (SARA).

As part of the Regional Peer Review process, a meeting was held on October 26-27, 2016, at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia, to review a science framework that could be used to establish the scientific basis to conduct an assessment of resource status and to provide management advice in a manner consistent with the Fisheries and Oceans Canada (DFO) precautionary approach.

The meeting chairperson, Tana Worcester, introduced herself, followed by an introduction of meeting participants (Appendix 1). The Chair then invited participants to review the meeting Terms of Reference (Appendix 2) and Agenda (Appendix 3). To guide discussion, three working papers were provided to meeting participants ahead of the meeting. This Proceedings document constitutes a record of meeting discussions and conclusions, and any statements within should not be attributed as being consensus-based. A Science Advisory Report was not a product of the meeting.

PRESENTATION AND DISCUSSION

SPATIAL DISTRIBUTION, AREA OF IMPACT ESTIMATES, AND ESTIMATES OF RECRUITMENT AND ADULT PRODUCTION

Working Paper: Bradford, R.G., and S. Smith. 2016. Spatial Distribution, Area of Impact Estimates for the Principal Sources of Human-Induced Mortality for American Eel (*Anguilla rostrata*), and Standard Estimates of Elver Recruitment and Adult Production for American Eel in the Maritimes Region. CSAM Working Paper 2016/16

Science Lead: R.G. Bradford
Rapporteurs: L. Bennett and S. Smith

Presentation Summary

The locations and number of watersheds within the Maritimes Region where human activities resulting in American Eel mortality occur were presented. The objectives are to better understand the scale of human effects and, using watershed area as a surrogate for available

rearing habitat, to estimate the proportion of the freshwater eel standing stock in the region that is subject to mortality from human activities. The total drainage (catchment) area of a waterway is used as an index of total habitat contained within. The principal sources of human-induced mortality that were considered were fisheries (large eel and elvers) and hydroelectric generating facilities (DFO 2014). In addition, a summary and update of the distribution and extent of occurrence of the invasive swim bladder parasite (*Anguillicoloides crassus*) in Maritimes Region waters (Campbell et al. 2013) was presented. The potential loss of adult American Eel production that results from infection by the parasite is not known at present; however, a negative impact is anticipated (COSEWIC 2012, DFO 2014).

It is expected that these data, in combination with reported/estimated losses from human activities, will be useful in assessing levels of mortality relative to precautionary reference points for the region and for individual watersheds.

Discussion

Overview Presentation

There was clarification on the terms used to define eels and elvers within the framework. An elver is defined as an eel that is less than one year river age and typically measures 6-7 centimeters (cm) total length; however, it was noted that in the *Maritime Provinces Fishery Regulations*, an elver is defined as an eel less than 10 cm total length. A yellow eel is defined as any eel older than an elver that has yet to sexually mature.

Up to 2008, records for eel fishing activities relative to location, catch per licence, and gear type for the Maritimes Region are considered poor. A re-designed logbook was available for the 2009 fishing season but logbook return rates to DFO remained low. Since the beginning of the 2015 fishing year, a policy has been in place that conditions of license are not issued until licence holders have submitted their logbooks from the previous year for data entry. Therefore, only the fishing locations from the 2015 and 2016 fishing seasons can be considered representative of the annual rates of participation in the eel fishery.

Spatial Distribution and Area of Impacts

Commercial, recreational, and FSC fisheries for eel exist throughout the Maritimes Region; however, there is currently no comprehensive means to document the scope and scale (e.g., locations, catch, effort) of either the recreational or FSC fisheries as reporting is mandatory only for the commercial fishery. The commercial eel fishery logbooks allow for the identification of specific river drainages that were fished and whether fishing activity occurred in tidal or non-tidal waters. The daily catches recorded in the logbooks are considered estimates because catches are usually weighed at the time of sale with eels captured over a period of several days representing the sold catch. However, since both estimated daily catches and the reported weight at the time of sale (buyer information) are recorded in logbooks, the accuracy of the estimates can be evaluated.

There was a discussion on the accuracy of the portrayed geographic scope of the commercial eel fishery and whether fisheries directed for yellow eels could be distinguished from fisheries that target migrating adult (silver) eels. It was stated that baited pots (which are identified in logbook records) indicate yellow eel fishing. Maturing and silver eels do not feed extensively and therefore are not attracted to bait. Weirs (defined as traps on licences), however, are installed in rivers during the autumn to intercept migrating silver eels (which comprise the bulk of the catches). Interpretation of the life stage being targeted by fyke nets is more difficult because these nets can intercept both yellow and silver eels. There would be considerable benefit to a review of the commercial records by DFO and industry (perhaps through an expanded and

more regionally representative eel fishery advisory committee process) of fishing practices. An invitation to review the commercial records was extended by industry to DFO.

It was clarified that logbook data for the eel and elver fisheries will be used to establish losses from fishing. Logbook data, along with information concerning losses associated with hydroelectricity generation, will allow overall losses from human activities within discrete watersheds to be estimated. Overall losses from human activities can also be estimated for the entire Maritimes Region. These losses will be evaluated relative to precautionary reference points that will be proposed during a formal stock assessment to help establish whether eel mortality is occurring at safe, cautious, or critical levels.

Participants expressed concern with the amount of latent effort in the large eel fishery. Comparisons of the number of gear reported being fished in logbooks to the amount of gear authorized for use under licence indicates that few licence holders have deployed all of their gear in recent years. This, however, could change with a strengthening of the market for eels, which could as well result in a higher participation rate in the fishery. It was stated that the amount of gear under licence may be reviewed for appropriateness in the future. The requirement that all licence holders report their annual fishing activity, including whether they fished, allows for detection of change in the fishery participation rate. Meeting participants indicated that information concerning the occurrence of, and the potential for, illegal elver fishing activities should be included within the working paper. Previously, records of prosecution or ticketing were used to judge the level of illegal activity.

Watershed Analysis

Participants noted that the relationship between fishing success and the size of the watershed drainage area should be included in the framework. The challenges with relating catch information and drainage area were discussed. Total catch and catch per effort by watershed would be considered during the stock assessment; however, with only the two most recent years of information for the eel fishery considered to be usable, the outcomes would be considered preliminary. Fishing success relative to the size of watersheds authorized for elver fishing will accordingly be a consideration during the stock assessment.

Reference points that will be proposed during the stock assessment will need to be based on biological traits of eel reported in published literature and/or contained in unpublished DFO Science data sets. These data should be considered as average values for the entire region until more geographically representative information concerning sex ratios, size/age of maturity, variability of traits among river drainages and habitat quality are acquired. A better understanding of intra-regional variability in life-history attributes, habitat quality, fishing and other human effects on freshwater resident eel populations could help develop reference points for specific types of habitat or sub-areas. Participants suggested that information concerning the use of habitat should be further explained in the working paper.

Hydroelectric Facilities

It was recommended that the working paper include additional information on the upstream and downstream passage of eels at hydroelectric facilities. Mortality rates associated with different turbine types at hydroelectric facilities could be estimated from published literature. Eel production rates are based on the ability of eel to access habitat; however, if downstream passage is unachievable, production rates (in terms of silver eels that could potentially contribute to spawning) will be overestimated.

Currently, only a single estimate of mortality is associated with downstream passage of eels through hydroelectric turbines; however, future analysis will aim to consider the cumulative

effects of mortality associated with upstream and downstream passage at multiple facilities, once watersheds are identified.

Meeting participants acknowledged that estimating mortality associated with hydroelectric barriers is a large but important task. DFO's Fisheries Protection Program documents reported fish kills but do not collect data on the magnitude of the mortality associated with the fish kill. In 2012-2013, DFO collected information on barriers, which was used to score the relative passability of the barrier. The analysis was completed on all rivers but only salmon rivers lying within the Southern Uplands (SU) area of Nova Scotia were reported on in Bowlby et al. (2014).

Swim Bladder Parasite

There was a discussion on the occurrence of the swim bladder parasite in eels. Relative to life-stage, the parasite has been documented in pigmented elvers and older eels. Relative to geography, the parasite is broadly (e.g., present from the border of New Brunswick and Maine to Cape Breton Island), but not contiguously, distributed throughout Maritimes Region watersheds. The reason for the patchy distribution of the parasite is unclear. It was noted that the baseline sampling conducted during 2008 and 2009 may now be somewhat dated given how rapidly the parasite appears to be able to spread to new waterways. There is no geographically representative survey dedicated to monitoring the status of the parasite, and the level of sampling that can be exerted towards monitoring will probably remain low.

Commercial eel fishers operating on the Medway River have noted a high prevalence of the parasite in the eels comprising their catches, and there is concern that the parasite is a source of stress for migrating silver eels. Silver eels that died during capture were subsequently shown to be carrying a relatively high parasite load. A number of university-based investigators have been collecting information on the distribution of the parasite and incorporation of their observations into the developing database of known presence would be beneficial. The effect of parasite load on the capacity of silver eels to migrate to the Sargasso Sea and spawn successfully is not known.

Given the potential impact to the fishery and lack of dedicated monitoring program, it was recommended by meeting participants that additional sampling and future research be completed on the mortality associated with parasite presence.

ELVER ABUNDANCE INDEXING METHODS

Working Paper: Bradford, R.G., and D. Pernette. 2016. Review of Methods Applied to Monitor Elver Runs at East River-Chester, Nova Scotia. CSAM Working Paper 2016/15

Science Lead: R.G. Bradford
Rapporteurs: L. Bennett and S. Smith

Presentation Summary

Monitoring of the timing, abundance, biological traits and commercial fishing exploitation rates on elver runs ascending the East River-Chester during the periods 1996-2002 and 2008-2016 was presented. These data potentially provide valuable insight into the dynamics of elver recruitment to Maritimes Region rivers, an index of elver recruitment, and allow for the assessment of fishing effects on eel abundance. Estimation of daily catches expressed as number of elvers was based upon a bulk volumetric (L) measure of total daily catch with conversion to number of elvers from sub-samples that relate elvers per unit volume to total volume. However, the sub-sampling protocols have varied among-years thereby raising

uncertainty in the accuracy, precision and general inter-annual comparability of the index. The objectives of the analysis were therefore to:

- describe the East River-Chester sampling protocols and changes with time,
- summarize the data available to generate run-size estimates for the years 1996-2002 and 2008-2015 and,
- present a method to reconstruct the time series of elver counts using a standard approach to convert elver weight-, elver length- and total volume-based estimates of daily catches to number of elvers.

The objective is to generate inter-annually consistent estimates of elver run size for the years up to and including 2015. In 2016, catch volume was replaced with catch wet weight as the bulk measure of total daily catch in order to allow for direct comparison with the reported commercial catches that have been reported as wet weights since 1996. Paired measures of catch volumes and catch wet weights were accordingly acquired during the 2016 sampling season to allow for conversion from one basis of measure to the other.

Discussion

It was suggested that because elver length exhibits a stronger inverse relationship with time than elver weight that length be used to estimate the number of elvers per unit volume, which in turn is used to estimate elver abundance. However, differences in annual elver run size estimates derived using elver weights versus elver lengths were relatively small and both series portray the same patterns of inner-annual variability in elver numbers. It was accordingly recommended that further reporting of the elver run size data for the years 1996-2002 and 2008-2015 present the series derived from elver lengths and elver weights. The total volume and/or total weight of the annual catches should also be reported as indices of elver run size.

There was a discussion on how best to portray the precision of the annual run-size estimates. The upper and lower confidence intervals presented in the working paper represented the summation of the daily estimates. However, the consensus view was that these should be weighted by the average daily catches. The confidence intervals will accordingly be re-calculated for reporting in the Research Document.

It was asked whether the clustered nature of the sampling (i.e., elvers are captured in 4 traps) results in among-sample variability in elver weights and lengths. It was clarified there is no difference in mean length or weights among traps on a given day.

To monitor the elver run and estimate run size on the East River, two traps are installed on each side of the river. Following estimation of elver numbers the catches from each box are released above the falls. The site selected in 1996 for release of elvers post-sampling was sited 85-90 m above the top of the falls. The release of elvers at this site, which required carrying the elvers in buckets to the riverside, appeared to contribute to post-release mortality. Since 2010, the release site has been located approximately 70 m upstream of the top of the falls, at the site where elver catch weights and volumes are measured, to reduce overall handling time and stress from transport in buckets. The working paper should document that while the protocols for moving the elvers have not changed, the location of the site has been moved 15-20 m closer to the falls.

It was questioned whether elvers released upstream fallback over the falls and, if so, if the level of fallback is sufficient to influence abundance estimates. While significant fallback has been reported for other species (e.g., gaspereau and Atlantic Salmon around dams), there is no evidence from mark-recapture studies for significant elver fallback at the East River-Chester

(Jessop 2000). It was suggested that this reference to elver fallback be incorporated into the working paper.

There was a discussion on the factors contributing to the start times of the commercial fishery. The commercial fishery normally starts to operate 10-14 days prior to the opening of the collection traps. During the early part of the run, the river is in freshet where cold water temperatures and/or water velocity can deter or prevent elvers from moving upstream. Collection traps are installed once water levels are low enough to enable elvers to move upstream. The working paper should provide the range and a rationale for the difference in the commercial fishery and collections start times.

Commercial catches are measured on the basis of weight as a condition of licence. Elver trap catches, which are measures on a volume basis, need to be converted to weight for comparison to commercial catches. Therefore, beginning in 2016, trap catches have been measured on the basis of weight to allow for direct comparison to commercial catch data.

Meeting participants agreed that it would be useful to have this working paper published as a product of this meeting rather than waiting until the assessment with the knowledge that there may be updates once the project is completed.

STATUS AND TRENDS INDICES

Working Paper: Bradford, R.G., H.D. Bowlby, and S. Smith. 2016. Status and Trends Indices for American Eel and Elver in the Maritimes Region. CSAM Working Paper 2016/17

Science Leads: H. Bowlby and R.G. Bradford
Rapporteurs: L. Bennett and S. Smith

Presentation Summary

Fishery-independent (eel electrofishing and East River-Chester elver index) and fishery-dependent (elver) data that are available to develop indices of regional stock status, to quantify losses from human activities, and to support the development of reference points for the Maritimes Region eel and elver fisheries were presented.

Fishery-Independent

Electrofishing

An abundance index of American Eel was developed from electrofishing surveys in watersheds throughout Nova Scotia and used to evaluate changes in the population trajectory (i.e. increases or decreases over time). Two data sets were developed. The first included information collected during 1995 to 2005 from watersheds draining into the inner Bay of Fundy (iBoF) and along the Atlantic coast (Southern Upland, or SU region) of Nova Scotia (28 unique watersheds; 360 unique sampling sites). The second data set included information just from the Southern Upland region but incorporated more recent years (1995 to 2013). Both data sets were analyzed by regression (Generalized Linear Mixed Modeling (GLMM) and a Generalized Linear Model (GLM)) assuming a negative binomial distribution of the response (first pass eel count), and incorporating an offset for sampling area. The GLMMs included the random effect of 'watershed'. These analyses gave evidence of large declines in first pass counts of American Eel over time (e.g. 89% over 10 years from a hurdle GLMM). These were consistent among the two regions (iBoF and SU) and appeared to extend to more recent years (up to 2013 – mainly based on data from two rivers). There was evidence (also from the hurdle GLMM) that zero counts of American Eel were more commonly observed in the SU region, and that zeros were

more commonly observed in more recent years in both regions. The mechanism leading to the declines is not known at present, but there is the potential to evaluate functional relationships between watershed characteristics or human impacts and the abundance index in the future.

East River-Chester Elver Index

The East River-Chester Elver Index estimates annual recruitment to the non-tidal portion of the river for the years 1996-2002 and 2008-2016. The recruitment index is based upon counts of elvers that are captured in traps installed below a natural impediment (a small falls) to upstream migration. The counts are not considered to be a complete census of the run to the head of tide, but the capture efficiency of the traps is considered to be very high. A commercial fishery for elvers occurs downstream of the index traps in most years. The trap counts in combination with the commercial catches allow for estimation of total run size to the mouth of the river. These data represent the longest time series available in eastern Canada to monitor inter-annual variability in elver run size to freshwater habitat and to assess the effects of fishing on elver recruitment. This manuscript explores the relationship between commercial elver fishing success and elver run size both in the East River-Chester and in other southwest Nova Scotia rivers with the objective of determining whether there is evidence that fishing success is an indicator of elver recruitment. If so then the inter-annual success of the fishery is a potentially credible index of recruitment, in which case fishery information could be used to estimate the East River-Chester elver run-sizes in the years that monitoring was not conducted (2003-2007). This could also allow for an exploration of elver recruitment on a much larger geographic scale than East River-Chester.

Fishery-Dependent

Commercial Catches

Logbook records of the commercial eel catch are not considered to be a reliable indicator of stock status prior to 2015, which limits their use at the present time. The elver fishery records that began in 1996 present a more complete record of fishing activity and fishing success. However, the process of data-truthing the available records (for all years and by all licence holders) was ongoing at the time of the meeting. As a result, it was decided that catch, effort, and fishing activity information for the entire elver fishery would not be used or reported at this time. Priority was given to data-truthing information for the licence holder who is authorized to fish East River-Chester to allow for its use when evaluating trends in run-size and exploitation.

Discussion

Electrofishing

The sampling methods used to generate indices were discussed at length. It was clarified that some sample sites were randomly selected (e.g. those on the St. Marys, LaHave or Stewiacke Rivers) while others were sampled opportunistically at fixed locations. In response to declining Atlantic Salmon populations, widespread electrofishing surveys were completed in 2003-2004 on rivers containing salmon habitat in the iBoF and SU region of Nova Scotia. Since 2009, electrofishing has been concentrated on two rivers in the SU region. Surveys were restricted by water level and temperature, which helps to standardize the hydrological characteristics of sites and meant that sites were concentrated in watershed tributaries. It was noted that since 2007, the focus of electrofishing surveys has changed from a Salmonid to a freshwater fish assemblage survey. There are instances where certain watersheds and/or certain sites have been sampled annually and instances where specific watersheds or sites within a watershed have been sampled sporadically.

The association between eel presence and Atlantic Salmon habitat type has not been examined. Participants requested that the working paper indicate that the targeting for sampling of supporting habitat for juvenile salmonids (e.g., riffles and small pools) may not be representative of riverine habitat use by American Eel, and that the electrofishing surveys are conducted in only a sub-set of eel habitat, which includes tidal waters and lakes. It was noted as well that the susceptibility of eels to capture by electrofishing varies with body size (large-bodied eels are more susceptible). The presenter indicated that these edits would be incorporated but further noted that an appropriate abundance index does not require sampling the entire population or understanding how relative density changes with habitat type; it requires that the sampling has been on a consistent component of the population over time. Changes in year-class strength could contribute to the decline in the index.

Modelling Approach

There was a discussion on the modelling approach. Participants asked if assumptions related to the chosen distribution had been evaluated (beyond using a negative binomial). The presenter indicated that other distributions had been considered in preliminary analyses (e.g. Poisson) and rejected on the basis of the Akaike Information Criterion (AIC) and AIC weights. Additional information concerning the approach would be incorporated into the working paper.

Whether it was appropriate to combine information from fixed stations and randomly chosen sampling sites was discussed. It was noted that the index of abundance was developed by combining data from various surveys that employed different methods and were not always active during the same time frame. If possible, it was recommended that the persistence of the fixed-station surveys be evaluated, and then surveys with a high degree of persistence could be included in the index. It was suggested that a separate index be developed from surveys that employed a random stratified design and presented to evaluate whether the same trend exists.

The presenter would investigate methods to account for persistence when fixed and random samples were combined. It was noted that restricting the analyses to one type of survey would make the entire dataset more sparse and unbalanced relative to the number of samples on each watershed per year. The presenter further noted that using data from the watersheds sampled using a random stratified design would result in higher estimates of decline rates.

A suggestion was made to use year as a categorical factor rather than a continuous variable in the regression, given that year effects represent categorical deviates of stock abundance in fisheries models. The presenter noted that this was inconsistent with an evaluation of trends because the order of the data points matters when describing a population trajectory. An analysis fitting the hurdle model with year as a factor was requested and presented during the second day of the meeting. Incorporating 'year' as a factor in the hurdle regression model does not change the magnitude of the predicted decline, but it shortens the time period over which the decline occurred (7 years not 10). It reduces the AIC of the model because the year of highest relative abundance was not in 1995 but 1998.

Using 'watershed' as a grouping variable was discussed relative to using spatial regression based on latitude and longitude of sites. The presenter noted that geographical proximity might not be the best indicator for how similar relative eel abundance might be, given that sites can be very close together but located in different watersheds or can be very far apart and located in the same watershed. If eel abundance might be different in different watersheds, spatial regression would be inappropriate.

The need for a zero-inflated analysis relative to one based on a negative binomial distribution was questioned. The presenter confirmed that this had been evaluated in preliminary model selection and would add text to the document.

Participants questioned whether changing the number of rivers included in the analysis would change the results. It was suggested that any future analysis include re-running models for years with many samples to determine if similar trends are present. The presenter noted that individual regressions could be run on data from the St. Marys, LaHave and Stewiacke Rivers; these were requested and presented during the second day of the meeting. Fitting a negative binomial GLM to data from individual rivers gives higher predicted decline rates than the GLMM analyses. Also, declines continue into recent years (2013).

It was noted that rivers with high random effects all drain into the Minas Basin, suggesting that these rivers may have higher underlying productivity or population sizes of American eel. There were questions related to the characteristics of the individuals sampled during electrofishing surveys. Concern was expressed that without length information, it was difficult to determine what may be causing the abundance index to change. It was recommended that the length and/or age range observed in the various surveys be summarized as the data would assist with interpreting the index. The presenter noted that these data did not exist for all of the sites included in the analyses, but catch at length could be evaluated from consistently sampled rivers (e.g. St. Marys, etc.). There was a research recommendation to evaluate length data and to include information on habitat similarity among surveys.

Modelling Results

Results of the analysis indicate an 89% decline in abundance index from 1985 to 1995, with no obvious regional pattern and no evidence that differences in pH among watersheds contributed to the decline. It was clarified that this is an index of abundance, not an absolute estimate and what this decline represents in the context of the eel population should be considered. The index of abundance reflects eels present in freshwater riverine habitat and not those that have settled in bays, estuaries, or lakes. The percentage of the population that settle in freshwater riverine habitat may vary annually independent of abundance but absence of information concerning eel standing stocks in non-riverine habitat precludes an evaluation at the present time. An additional consideration is whether upstream migration distance is density-dependent (e.g., high eel densities in the lower sections of rivers compel eels to migrate further upstream). This consideration was evaluated and presented during the second day of the meeting. Plotting first pass eel density at a site against the amount of watershed area above the site (aka the inverse of site position from head-of-tide) gives no evidence of density-dependent dispersal. Often, the highest densities were recorded at sites very high up in the tributaries.

If this analysis was considered for future work, a broader data set over a longer period is required to describe current regional trends. Additional sites that consider the range of habitat types should also be included in future electrofishing surveys. The presenter noted that if future surveys were designed to be more effective at catching American Eel, this could lead to a positive population trajectory even if abundance has not changed.

The benefits of integrating datasets from various programs were discussed. The following data sources could be considered for future analysis: data from 2013 and 2014 electrofishing surveys completed in the Gulf Region, electrofishing re-licencing data collected by Nova Scotia Power on the 13 rivers in Nova Scotia where they generate hydroelectricity, data collected by the MCG as part of region-wide electrofishing surveys, as well as data collected for the Aboriginal Fund for Species at Risk programs.

East River-Chester Elver Index

It was clarified that elver recruitment to the East River-Chester is defined as the total run size – the sum of estimated removals by commercial fishing and elver escapement past the fishery

(the catch in the elver traps). It was suggested that elver escapement replace the term escapement in all figures and tables associated with the East River-Chester elver index.

It was recommended that the estimates of annual run-size and escapement should be weighted by the daily catch sizes to better estimate the standard error around the annual estimates.

It was suggested that a Mann Kendall test, rather than a linear regression, may be more appropriate for evaluating temporal trends. The Mann Kendall test assesses if there is a monotonic upward or downward trend over time, even if there is a seasonal component to the time series. A parametric linear regression requires that the residuals from the fitted regression line be normally distributed; an assumption not required by the Mann Kendall test, which is a non-parametric (distribution-free) test. The suggestion was accepted.

Total annual juvenile eel catch in the index traps exhibited a stronger positive relationship with elver escapement from the previous year than with total elver run size, thus indicating eel recruitment to freshwater is more strongly associated with the elver run to the river than to the estuary (assuming some proportion of elvers that would settle in tidal waters recruit to freshwater at river age 1+ years). It was suggested that juvenile catches should be assigned to age classes.

There was discussion on the handling of juvenile eels intercepted in the elver fishery given that many juveniles are < 10 cm Total Length and therefore meet the legal definition of an elver. Commercial licence holders in attendance affirmed that they are a regular component of the catch and that whenever possible these are culled from the catch at the riverside and returned to the water.

There was a discussion on how representative the run size and escapement estimates on the East River-Chester (ER-C) are to the Maritimes Region. Direct comparisons are not possible because there is only one index river. However, the general tendency for fishing success throughout the region to vary inter-annually in a similar fashion suggests that elver run-size variability has a geographic component.

Direct pair-wise and group-wise comparisons of trends in fishing success by river are difficult because elver licences authorize individual licence holders to fish several rivers to fill their quota. Fishing effort is not evenly distributed across all of the rivers identified in a single licence for the duration of the season because licence holders are motivated to reach their quota and vary effort among rivers to maximize catch. Nonetheless, plots of annual reported elver catches for one licence holder by river when compared to the East River-Chester index of total run size suggests that the Index may reflect elver recruitment to a broader geographic area. Many of the river-specific series of landings exhibited a positive relationship to the Index. However, future work should incorporate information pertaining to effort as well as catch and effort by gear type. River size was also suggested as a future consideration since exploitation rate cannot be assumed to be the same among-rivers. Participants suggested separating cases where multiple gear types have been used to ensure similar catches are being compared.

Since the elver fishery is managed through quotas, there is an upper limit on total catch and a censored regression approach was recommended for the calculation of indices. This approach is designed to estimate linear relationships between variables when there is censoring in the dependent variable. Due to *Privacy Act* considerations, data for individual license holders cannot be displayed; however, it was recommended that alternative reporting approaches, which do not divulge confidential data, be examined.

A variety of data summaries were presented to support group discussion on approaches to modelling the elver fishery and its relationship to elver recruitment as estimated by the east River-Chester Index. It was generally agreed that data standardization will be important.

It was suggested that the data summaries presented to support discussion on modelling approaches should not be included in the final document. Rather, the focus of the working paper should remain on those elements of the analyses that to date are well developed and are expected to be useful for further development. Information and figures pertaining to the juvenile count work should remain in the working paper.

There was general agreement that monitoring elver run-size on another moderately sized river would be useful. It was noted that the estimates from the two East River locations (East River-Chester and the previously monitored East River-Sheet Harbour from 1990 to 1999) are not directly comparable. The East River-Sheet Harbour index was a partial count whereas the East River-Chester index generates a census estimate for the entire annual run to the river. Until the underlying data used to generate the East River-Sheet Harbour index is reviewed, a conservative approach should be taken with interpretation of these data.

It was suggested that a decreasing trend in elver recruitment (East River-Chester index) that results in a decline in total run size below the previous low of the time series could be one possible trigger for an early assessment

REFERENCE POINTS

Presentation: American Eel: Framework for developing Spawner Per Recruit Reference Points

Science Leads: A. Cook
Rapporteurs: L. Bennett and S. Smith

Presentation Summary

Spawner Per Recruit or Spawner Potential Ratio (SPR) has been suggested (ICES 2001) as a basis to develop harvest strategies and reference points for the American Eel. The International Council for the Exploration of the Sea (ICES) proposed SPR reference points as 30% and 50% of the unfished biomass as the limit and target. SPR models are simple age or size structured models that incorporate life history variables. This presentation described development of an SPR model for Maritimes Region with particular consideration to eel and elver fisheries. The model can accommodate mortality from other sources, e.g., that associated with hydroelectric generating facilities as these data become available.

Available data to support SPR analysis for Maritimes Region eels includes: length and weight at age, vulnerability to removal by fisheries at age (single or multiple fisheries), sex ratio at maturity, fecundity at age, maturity at age (for males and females), and generalized estimates of mortality at age.

Model output showed the sensitivity of SPR to life-history characteristics, which are expected to vary among-rivers in Maritimes Region. A particular consideration for Maritimes Region where eel are exploited at the elver, yellow, and silver eel stages, is the appropriateness of the SPR_{30} and SPR_{50} as lower and upper precautionary reference points. Eel sexual maturation can occur from 10-40+ cm, following recruitment as elvers. Stochastic events therefore can potentially significantly influence mortality over a lengthy period of time, a factor that requires specific consideration when evaluating fishing effects on elvers.

Discussion

Participants questioned whether 30% and 50% are appropriate reference points for an elver fishery. The proposed work is not designed to define fishing mortality (F) reference levels for the Maritimes Region but is a potential way of moving forward.

There was a discussion on the challenges associated with SPR reference points. The impact of dams on preventing upstream passage as well as density dependent mortality of eels aggregating below dams is difficult to estimate. Secondly, estimating mortality at early life stages in the Maritime region is also challenging. In the Gulf Region, large numbers of yellow eels are present in bays and estuaries unlike the Maritimes Region where large numbers of elvers are present in estuaries. It is inferred that mortality rates of eel at an early age is higher in the Maritimes Region than in the Gulf Region (likely a result of density).

The mortality of other life stages due to the elver fishery was not accounted for in the model; however, by modifying the selectivity curve, the number of juvenile eel caught in the elver fishery, the interactions between an elver and eel fishery, and other sources of mortality can be included in the model. It was noted that some larger sized 'elvers' (juveniles <10 cm Total Length that meet the legal definition of an elver) are retained in the net and not all are returned to the river. When these fish are culled at holding facilities, where they have been trucked live, they are usually euthanized since they cannot be returned to the river for fish health reasons. Culls represent a source of mortality on a non-targeted age class and should therefore be recorded in logbooks separately from the number culled at the river side. Culls that occur at holding facilities are counted against the harvest quota.

Three-dimensional harvest control rules can be developed on a watershed basis and completed on a plane rather than a 2-D plot. This would enable the interactions of multiple factors to be examined.

There was also discussion on the application of a SPR model to rivers with multiple and different stressors (e.g., water quality, hydroelectricity generation, large eel- versus elver-fishing). In rivers with different stressors, population weighting in terms of potential contributions based upon amount of rearing habitat and productive capacity would help; however, an estimate of regional escapement target is still needed. Reference points would be difficult to apply to the large eel fishery which is effort based and licenced by county rather than for specific watersheds. To evaluate reference points in the context of the harvest control rule, an estimate of exploitation level would need to be determined.

The need for establishing natural mortalities was highlighted. Until additional information is collected, it was suggested that fishing on a river remain limited to either large eels (yellow and silver stages) or to elvers.

In the development of reference points, data collected by Aboriginal communities with FSC fisheries on harvest levels and locations with a significant FSC fishery was identified as a data source that could be further utilized.

Several approaches for selecting the fishing mortality that would be used to compare against reference points was discussed. In the first approach, the fishing success (total catch and/or catch per effort) of a river would be compared to the East River-Chester with harvest levels allocated based on the proportional size of the drainage areas. Once a baseline is calculated, rivers could be sampled approximately every 5 years to determine if the trends for the index have changed. An alternative approach suggested the use of relative F calculated as the catch of the Maritimes Region/index for the Maritimes Region. Ideally, relative F should be proportional to actual F. Using relative F, it was questioned whether an index could be developed using only the yellow and silver eel commercial harvest data without reference to the East River-Chester, where an elver abundance index is available and information on yellow and silver eel abundance is being acquired. Moving forward, this could be explored and better use of the size information that is available should be made.

ASSESSMENT SCHEDULE AND TRIGGERS

While a date was not selected, it was decided that a peer reviewed assessment would occur no earlier than the fall of 2017 due to the time required to correct information gaps in the commercial elver and large eel fishery data. Following the framework, commercial data will be provided to licence holders for review and correction, where necessary.

It was recommended that an assessment of the freshwater component of the elver fishery be completed every five years. The stock assessment would evaluate elver catches, the harvest of large eel from specific drainages, and status relative to reference points; however, a population estimate will not be provided. A stock status update will be completed in the interim years. It was proposed that the stock status update would report on the recruitment from the elver index and total landings from the elver fishery. It was acknowledged that in the future, if a decision is made to add American Eel to the List of Wildlife Species at Risk under SARA, this would change the fisheries management context, both in term of data availability from fisheries, and management needs for science advice.

Participants raised concerns about the exclusion of data on large eels in the assessment. If annual indices are focused on the status of the elver fishery, there is nothing to indicate any impacts to the commercial and FSC fisheries. Elver-based indices provide an indication of the number of elvers entering the system. These indices could be linked to abundance indices for older age classes (e.g., incorporation of age structure into electrofishing surveys to monitor for inter-annual variability in recruitment). The time series of catch data for large eels is very short, which limits its usefulness in the near term. As well, there is uncertainty in the distribution of fishing activities within specific river drainages (licences are issued for a county) and there are constraints on the reporting of eel catches owing to the need for reporting to be compliant with the *Privacy Act*. It is unclear if data from the weir fishery, which targets silver eels, could be reported in aggregate without violating the *Privacy Act*. As eels and elvers in the Maritimes Regions are only a portion of a single, larger population, data from the Gulf Region should also be evaluated since there is no elver fishery in that Region.

Traditional Ecological Knowledge is a source of information that could be used with respect to the SPR model, which requires data on the spatial distribution and abundance of eel in the absence of exploitation; however, consideration on how to incorporate Traditional Ecological Knowledge needs to be given. A meeting participant offered to provide a paper that documents how Indigenous Knowledge from fishers in Eskasoni can be incorporated into policy decision making.

DOCUMENTS

This Proceedings document constitutes a record of meeting discussions and conclusions, and any statements within should not be attributed as being consensus-based. It was decided that all three working papers should be published as Research Documents. A Science Advisory Report will not be a product of the meeting.

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APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Name	Affiliation
Bennett, Lottie	DFO Maritimes / Centre for Science Advice
Bowlby, Heather	DFO Maritimes / Population Ecology Division (BIO)
Bradford, Rod	DFO Maritimes / Population Ecology Division
Cairns, David	DFO Gulf / Science
Carey, Yvonne	Canadian Committee for a Sustainable Eel Fishery
Chandler, Alan	NS Department of Fisheries and Aquaculture
Cook, Adam	DFO Maritimes / Population Ecology Division (BIO)
Davis, Donald	Waycobah Fisheries / Fisheries
Denny, Junior	Mi'gmawe'l Tplu'taqnn Incorporated (MTI)
Dixon, Brittany	University of New Brunswick
Estabrooks, Renee	J.D. Irving Ltd.
Feigenbaum, Mitchell	License Holder
Giles, Amber	Malliseet Nation Conservation Council
Giroux, Brian	Shelburne Elver
Holland, Mary Ann	Brunswick Aquaculture Ltd
Hussey-Bondt, Laura	DFO Maritimes / Resource Management
Jacobi, Carol	DFO Maritimes / Fisheries Protection Program
Jayawardane, Aruna	Maliseet Nation Conservation Council (MNCC)
Kavanagh, Sana	Confederacy of Mainland Mi'kmaq (CMM)
Lawrence, David	Morgan Falls Power Company
Lee, Laura	North Carolina Department of Marine Fishes
MacIntosh, Robert	DFO Maritimes / Policy and Economics
McIsaac, Allison	Eskasoni Fish and Wildlife Commission (EFWC)
McNeely, Joshua	Maritime Aboriginal Peoples Council (MAPC) - IKANAWTIKET
Nodding, Brooke	Bluenose Coastal Action Foundation (BCAF)
O'Hara, Claude	Glooscap First Nation Economic Development Corp. (GFNEDC)
Pernette, Danielle	Bluenose Coastal Action Foundation
Perrier, Erika	Atlantic Policy Congress of First Nations Chiefs
Pratt, Thomas	DFO-Great Lakes Laboratory for Fisheries and Aquatic Sciences
Smith, Sean	DFO Maritimes / Population Ecology Division (BIO)
Walmsley, Jay	NS Power Inc
Wamboldt, Louis	License Holder (Medway River)
Ward, Devin	Mi'gmawe'l Tplu'taqnn Incorporated (MTI)
Worcester, Tana	DFO Maritimes / Centre for Science Advice Maritimes

APPENDIX 2: TERMS OF REFERENCE

Stock Framework for American Eel and Elvers

Regional Peer Review – Maritimes Region

October 26-27, 2016
Dartmouth, NS

Chairperson: Tana Worcester

Context

The American Eel, *Anguilla rostrata*, is a widely distributed fish that occurs from northern South America to Greenland and Iceland. They are panmictic (all are members of a single population), catadromous (spawn at sea and spend a portion of their lives in freshwater) and semelparous (a single reproductive episode followed by death). Spawning occurs in the Sargasso Sea well to the south of Canadian territorial waters. Juveniles recruit as glass eels (elvers) to Canadian continental waters in the year following the year of their hatch. In Canada, the American Eel can be found in nearly all the accessible fresh, brackish and coastal waters from the Canada-United States of America border in the south to Lake Melville, Labrador in the north, including the Laurentian Basin of the provinces of Ontario and Québec and the island of Newfoundland. They have historically been fished for commercial and recreational purposes and by indigenous peoples for Food, Social, and Ceremonial (FSC) purposes throughout much of their Canadian range. The Maritimes Region commercial fishery is the only eel fishery in Canada that results in the removals of eels as recruits (glass eels or elvers), as well as juveniles (yellow eel), and adults (silver). All removals by fisheries occur pre-spawning.

The status of the eel and elver fisheries in Maritimes Region was last assessed in 1996 (Jessop 1996a,b). More recently, indices of general status were compiled in support of a national pre-COSEWIC and Recovery Potential Assessment of the American Eel (Bradford 2013; DFO 2014) and to help measure progress towards reducing human-induced mortality by 50 percent (DFO 2010). The 2012 COSEWIC assessment designated the American Eel as threatened. They are currently under consideration for listing under the *Species at Risk Act* (COSEWIC 2012).

In support of the 2017 American Eel and elver fisheries, DFO Maritimes Fisheries and Aquaculture Management has asked DFO Science for an assessment of resource status and the consequences of various harvest levels and strategies. A Framework is required to establish the scientific basis for the provision of advice to management in a manner that is consistent with the DFO precautionary approach (DFO 2009). The assessment of the stock will be completed in January 2017, following the completion of the Framework.

Objectives

The objectives of this regional peer review are:

- Review biological and ecological information (e.g. life-history, demographic data).
- Review fishery-dependent and fishery independent eel and elver data inputs for developing indices of regional stock status, quantifying losses from human activities, and supporting the development of reference points for the Maritimes Region eel and elver fisheries.
- Develop the assessment schedule, interim reporting procedures and how indicators would be used to trigger an earlier than scheduled assessment.

Expected Publications

- Proceedings
- Research Document(s)

Participation

- DFO Science
- DFO Resource Management
- DFO Policy and Economics
- Aboriginal Communities / Organizations
- Provincial Governments (NS and NB)
- Industry Representatives
- Environmental Non-Government Organizations
- Academics

References

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APPENDIX 3: MEETING AGENDA

Stock Framework for American Eel and Elvers

Regional Peer Review – Maritimes Region

October 26-27, 2016
Bedford Institute of Oceanography
Dartmouth, NS

Chairperson: Tana Worcester

DRAFT AGENDA

DAY 1 (Wednesday, October 26, 2016)

Time	Topic
9:00 – 9:15	Welcome and Introductions
915 – 9:25	Overview of American Eel life History
9:25 – 10:15	Synthesis of Spatial Organization of Human Activities that Result in Significant Mortality
10:15 – 10:30	Break (coffee/tea provided)
10:30 - 12:00	Review of East River-Chester Elver Abundance Indexing Methods
12:00 - 1:00	Lunch (hospitality not provided)
1:00 – 2:30	Status and Trends Indices
2:30 - 2:45	Break (hospitality not provided)
2:45 - 4:30	Status and Trends Indices

DAY 2 (Thursday, October 27, 2016)

Time	Topic
9:00 – 9:15	Recap of Day 1
9:15 – 9:45	Status and Trends Indices
9:45 - 10:15	Life-history Modelling and Development of Reference Points
10:15 – 10:30	Break (coffee/tea provided)
10:30 – 12:00	Life-history Modelling and Development of Reference Points
12:00 – 1:00	Lunch (hospitality not provided)
1:00 – 2:30	Proposed Assessment Schedule and Interim Reporting
2:30 – 3:00	Wrap up